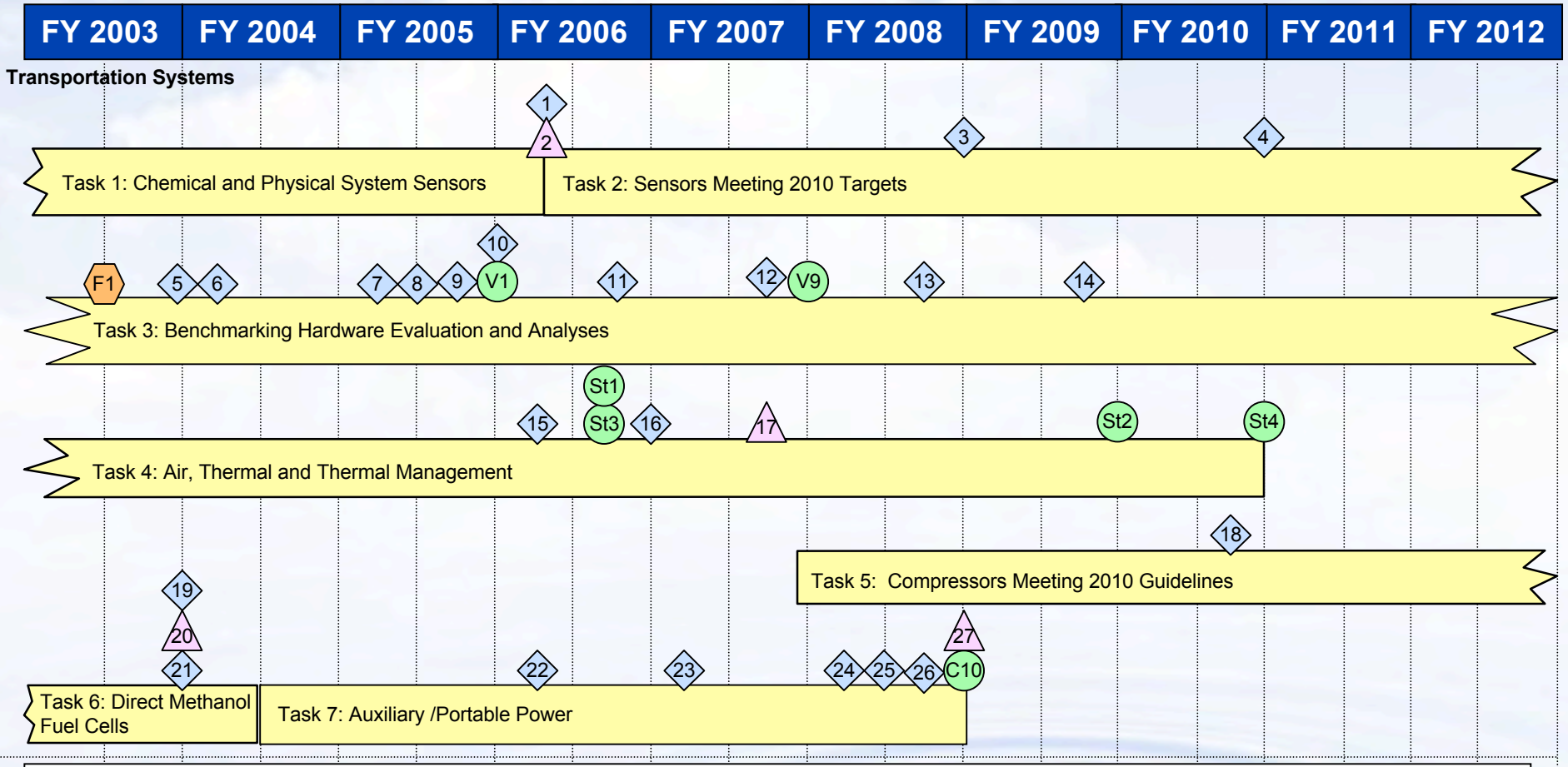
# Fuel Cell Barriers

**A. Durability**
**B. Cost**
C. Electrode Performance
D. Thermal, Air, Water Management
E. Compressors/Expanders
F. Fuel Cell Power System Integration
G. Power Electronics
H. Sensors
I. Hydrogen Purification/CO Cleanup
J. Startup Time/Transient Operation

# Technical Tasks

| Technical Task | Description |
|---|---|
| Develop membranes that meet all targets | • Identify ionomers & fabricate membranes<br>• Test and characterize membranes |
| Develop electrodes that meet all targets | • Improve catalysts & catalyst supports<br>• Optimize electrode design & assembly |
| Develop MEAs that meet all targets | • Integrate components & expand operating range<br>• Test, analyze & characterize MEAs |
| Develop gas diffusion layers | • Improve GDL performance & durability<br>• Develop testing protocols and characterization methods |
| Develop bipolar plates | • Improve performance & durability; decrease cost |
| Develop seals | • Improve durability & performance |
| Develop balance-of-plant components | • Develop sensors & air management technologies<br>• Develop water & thermal management technologies |
| Develop stationary and other early market fuel cells | • Develop stationary FC systems, APUs, and fuel cells for portable power and off-road applications |
| Conduct analysis | • Conduct cost & tradeoff analyses; increase understanding of durability and freeze issues |
| Characterize and benchmark fuel cells | • Benchmark fuel cell technology; develop testing protocols<br>• Investigate impact of impurities on fuel cell performance |
| Develop innovative concepts | • Improve BOP designs and FC performance |

# Fuel Cell R&D Milestones




**Milestones**

**1 Complete development and testing of low-cost, high-sensitivity sensors.**

**2 Go/No-Go: The status of sensors and controls technologies will be assessed and compared with the established technical and cost targets. Based on the assessment and the degree of success, the technologies will be released for use, more development will be indicated, or effort will be terminated.**

# Research Partners

**BOP Components**

*(delayed) Honeywell (2), Advanced Fluids Tech. (SBIR)*

**Characterization and analysis**

*NIST, ORNL, LANL, LBNL, ANL, TIAX, DTI, Battelle (revised)*

**Membranes**

*3M, Arkema, DuPont, Plug Power, LANL, ANL, NREL, SNL, Colorado School of Mines, Penn State, Virginia Tech, Giner, U of Tenn, Case Western Reserve U (2), FuelCell Energy, Clemson U, GE Global Research, Arizona State U, U of Central Florida*

**MEAs**

*UTC Fuel Cells, 3M, DeNora*

**Catalysts**

*Ballard, U. of South Carolina, 3M, Cabot-Superior Micropowders, NRL, NASA/JPL, ANL, LBNL, BNL, Farasis Energy (SBIR), NuVant Systems (SBIR), Engelhard, Ion Power*

**Bipolar Plates**

*Porvair, ORNL, PNNL, NREL, Nanosonic (SBIR)*

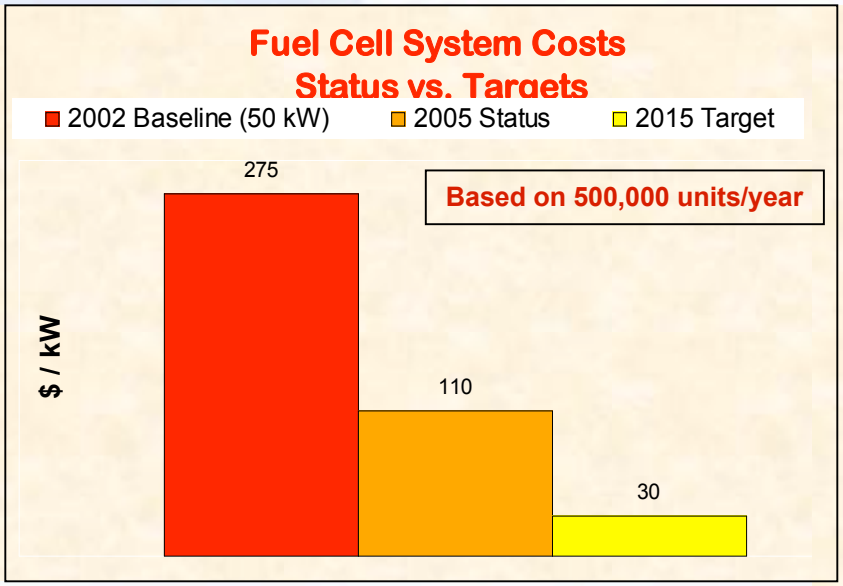
**Stationary and other early market Fuel Cells**

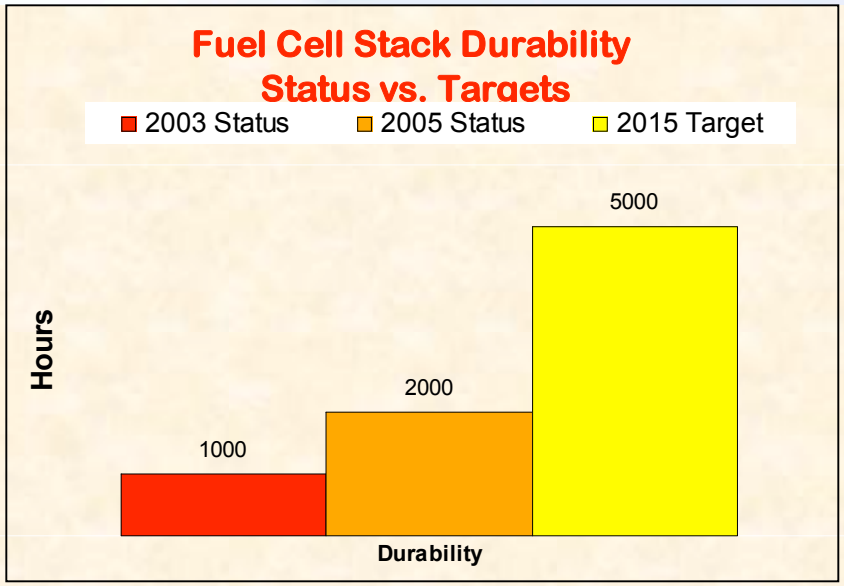
*(delayed) IdaTech (2), UTC Fuel Cells, Plug Power, Nuvera, ChevronTexaco, Delphi, Cummins, PolyFuel, MTI Micro*

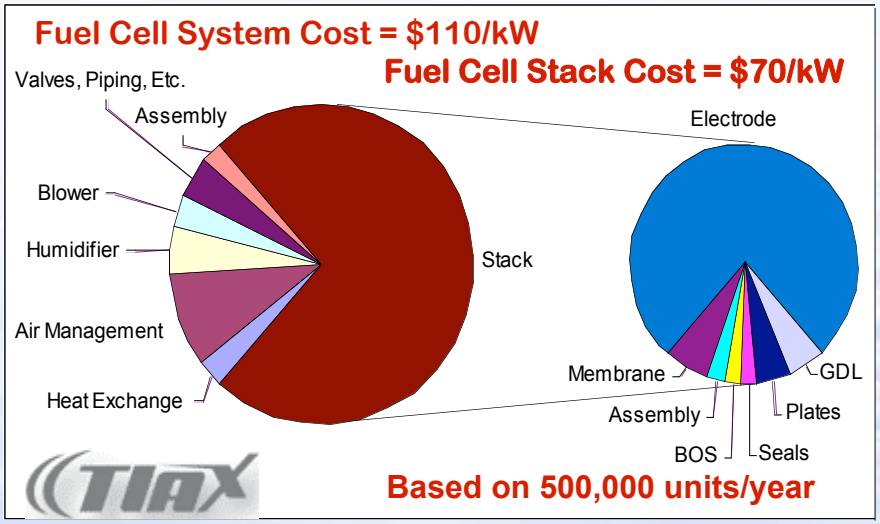
**FY 2005 & FY 2006 Congressionally Directed Projects**

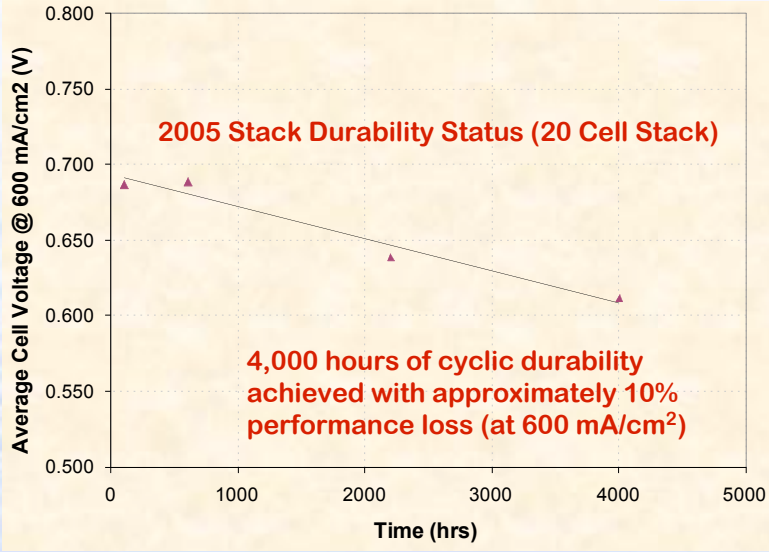
*OSRAM Sylvania, Del Co. Electric Coop, U of S. Carolina, U of Akron, U of S. Miss., UTCFC, Kettering U*

# Accomplishments: Reduced Cost and Increased Durability



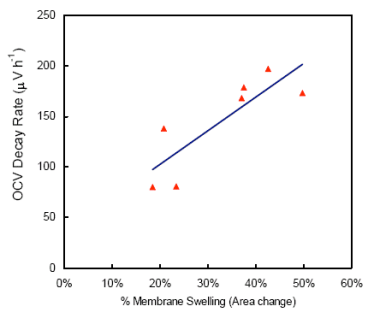



# Fuel Cell Development Highlights

## Durability improvements, MEA & PEMFC



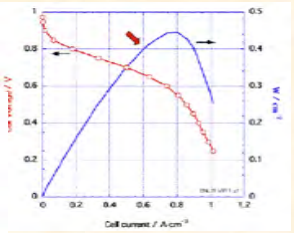

Data for 7 membrane types: reducing swelling percentage by reformulating the membrane, reduces degradation rate

***DuPont/ UTC***

## Higher FC catalyst activity with less Pt

Synthesis

Au + Ni co-deposit — At 600°C Au segregates — Pt deposited by replacing Cu

***BNL, MEA testing at LANL***

4x Pt kinetic activity (RDE) & mass activity in FC consistent w/ <0.2mgPt/kW

## Improved high current activity of non-Pt catalysts

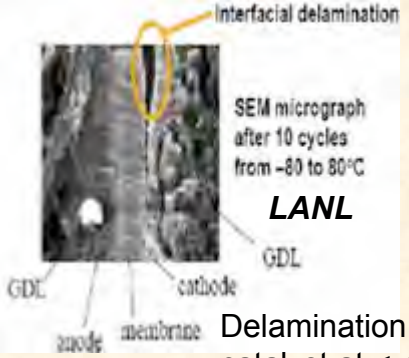
Density 2/3 that of state-of-art Pt

Pyropolymer CoTMPP

Poly ($CoN_4C_{36}$)$_n$

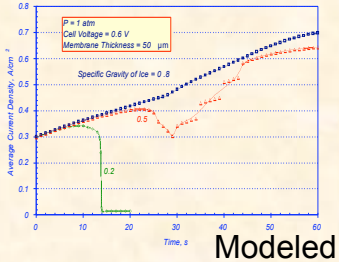
***LANL***

## Subfreezing effects & analysis




***LANL***

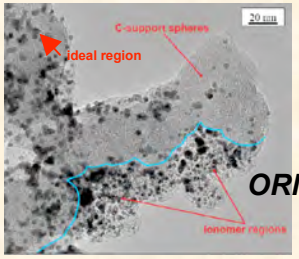
Delamination of cathode catalyst at <-40°C




***ANL***

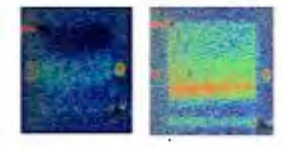
Modeled startup from subfreezing conditions (<30 s)

## Improved characterization imaging




***ORNL***

TEM imaging of new & used FC components

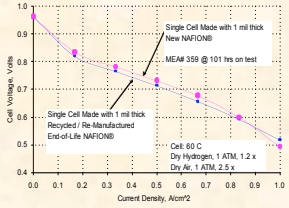


***NIST, SNL, et al***

Real-time imaging of $H_2O$ in FC components during operation

## Developed FC with remanufactured membrane

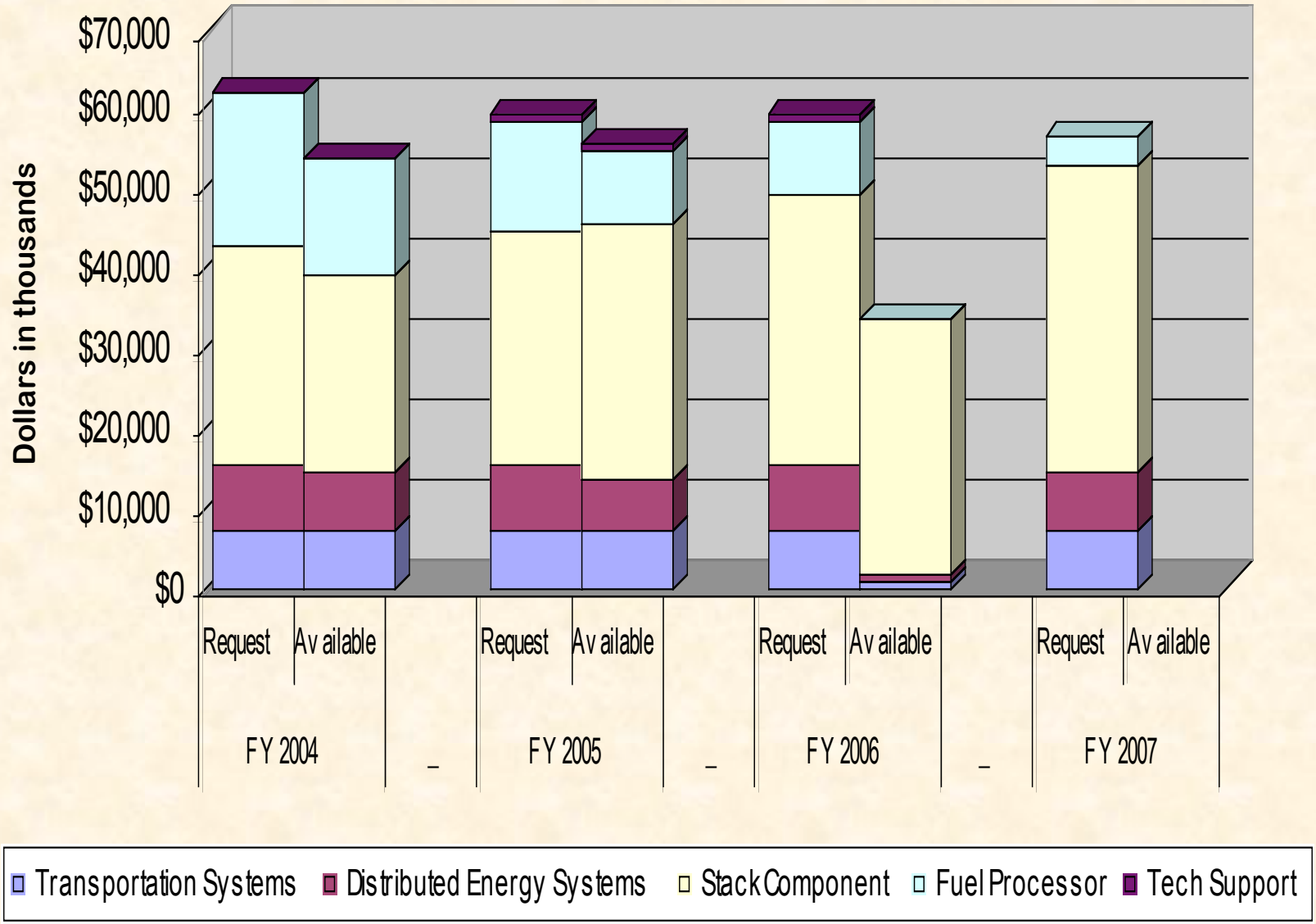
98% of Pt dissolves after holding at elevated temp & pressure




***Ion Power, Engelhard***

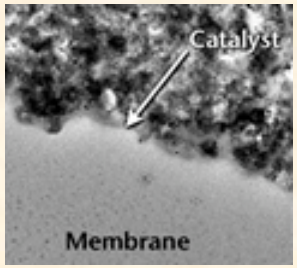
First operating FC w/ remanufactured membrane/downselect Pt separation procedures

# Fuel Cell Budget



# Fuel Cell Solicitation and Lab Call

- **$100 million DOE share over 2-4 years**
- **Primary focus is on fuel cells for transportation applications**
- **R&D is focused on components rather than systems**




**Membranes**

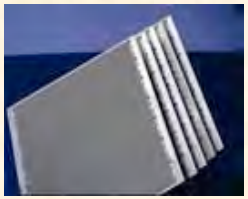
**Cell Hardware (bipolar plates & seals)**

**Catalysts & Supports**

**Effects of Impurities**

**Water Transport Within the Stack**

**Innovative Concepts**



**Stationary Demonstration (1-5 kW)**

The Office of Basic Energy Sciences announces opportunities for ***Basic Research for the Hydrogen Fuel Initiative***. The **deadline** for all mandatory preapplications or preproposals is **4:30 pm EST, July 6, 2006**. http://www.sc.doe.gov/bes/hydrogen.html

# Technology Validation Effort

***Provides Public, Congress, Stakeholders an Independent "risk assessment"***

- Conduct learning demonstrations of hydrogen infrastructure in parallel with hydrogen fuel cell-powered vehicles to enable and assess technology readiness for a 2015 commercialization decision.
  - **Not a "Commercialization" demonstration to prepare the market**

## Major Objectives

- Obtain detailed component data under real-world conditions (climatic, geographic etc.) to re-focus the Department's hydrogen and fuel cell component and materials research
- Validate the technology against time-phased performance-based targets, by 2009
  - **2,000 hour fuel cell durability**
  - **$3.00 per gge (full scale, hi vol.)**
  - **250 mile range**

DaimlerChrysler


Ford Motor Company

Hyundai

General Motors


BP LAX refueling station

DTE/BP Power Park, Southfield, MI

Shell hydrogen and gasoline station Washington, DC

ChevronTexaco, Chino, CA

# Tech Validation Teams

ChevronTexaco

HYUNDAI

UTC Fuel Cells
A United Technologies Company

DAIMLERCHRYSLER

bp

GM

Ford

bp

President Bush at
Benning Road Filling Station
Washington DC

# www.hydrogen.energy.gov

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